

TABLE 1.—*Solar radiation intensities at Santa Fe, N. Mex., during September, November, and December, 1915.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
A. M.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.	Gr-cal.
September 27...	1.48	1.48	1.43	1.37	1.29	1.21					
A. M.											
November 4...	1.52	1.47									
5...	1.53	1.48									
8...		1.51	1.42	1.33	1.25	1.18					
11...	1.63	1.56	1.49	1.42	1.36	1.30					
12...	1.66	1.61	1.55	1.48	1.42	1.36	1.32				
13...	1.58	1.49	1.39	1.26	1.17	1.13					
15...		1.53	1.43								
17...	1.63	1.55	1.47	1.35	1.30	1.22					
18...	1.63	1.54	1.46	1.38	1.31	1.29	1.25	1.21			
20...	1.57	1.52	1.43	1.38	1.32	1.26	1.22	1.17			
23...		1.47									
26...		1.53	1.46	1.39	1.33	1.27					
29...		1.51	1.44	1.38							
30...			1.46								
Means...	1.59	1.52	1.45	1.37	1.31	1.25	1.26	(1.19)			
A. M.											
December 1...		1.51	1.43	1.34	1.27	1.22	1.17	1.12			
3...		1.53	1.44								
7...		1.52	1.44	1.35	1.27	1.20	1.12				
8...		1.52	1.44	1.40							
9...					1.31	1.19	1.16	1.13			
11...		1.47		1.29							
17...		1.50	1.48	1.40	1.33						
21...			1.43	1.36	1.27	1.23					
22...		1.49	1.42	1.36	1.31	1.21	1.13				
23...			1.38								
24...		1.59	1.53	1.43	1.35	1.30	1.20				
Means...		1.52	1.44	1.37	1.30	1.24	1.16	(1.12)			

A HALO IN THE MAKING.

By J. R. WEEKS, Local Forecaster.

[Dated: Binghamton, N. Y., June 23, 1915.]

At Binghamton, N. Y., on December 18, 1914, occurred one of those peculiar mornings when the cold air settles in the Susquehanna and Chenango River Valleys, which here run north and south, and abnormal cold is experienced, accompanied by a deposit of hoarfrost. The temperature on this occasion fell to -7°F. at 8 a. m., while neighboring cities in New York and New England at the same hour had much higher temperatures, as shown in Table 1.

TABLE 1.—*Temperatures, December 18, 1914, to nearest whole even degrees at New York and New England stations.*

	Lowest.	At 8 a. m.		Lowest.	At 8 a. m.
	$^{\circ}\text{F.}$	$^{\circ}\text{F.}$		$^{\circ}\text{F.}$	$^{\circ}\text{F.}$
Binghamton, N. Y....	-8	-7	Canton, N. Y.....	14	18
Ithaca, N. Y.....	4	4	Scranton, Pa.....	4	4
Syracuse, N. Y.....	8	8	New York, N. Y.....	18	18
Rochester, N. Y.....	10	10	Albany, N. Y.....	10	10
Buffalo, N. Y.....	12	12	Northfield, Vt.....	-6	-4
Oswego, N. Y.....	14	14	Boston, Mass.....	16	18

Usually such a condition does not occur unless the center of high barometer, which brings the clear sky and increased nocturnal radiation, is located over or north of this locality. But in this instance the center of high pressure was on the North Atlantic coast.

The hoarfrost began to gather on the trees and exposed objects before sunrise and remained until about 11 a. m., being heaviest just after sunrise. The temperature did not begin to rise until about 10:15 a. m. The rivers

were covered over much of their course with ice, but there were numerous open spaces where the swiftness of the current prevented ice formation. In such localities mist wreaths rose from the water to a height of 4 to 15 feet and then disappeared in the air. Only a portion of the hoarfrost and fog is believed to have reached the air from this source, the remainder being condensed from the air itself. The mist ceased rising from the water at about 11 a. m. The average depth of snow on the ground was 8 inches.

The light fog began to form before sunrise, probably when the temperature reached the neighborhood of 0°F. , and continued in the air all day, though it was not very noticeable after noon. It reached a maximum density at about 8:30 a. m. At that time objects a thousand feet distant were visible, but the landscape beyond merged into a white obscurity. The hills, distant a half mile, were invisible and the white fog rose from the horizon to an elevation of 20° to 25° , gradually blending into the milky blue that covered the remainder of the heavens. The fog was composed of snow and ice crystals that were just at the limit of visibility to the naked eye. The general appearance of these was not that of spicules, but rather of 6-pointed star shapes of very small size. At 10:30 a. m. the fine deposit that gathered on the sidewalks was examined with a microscope and found to consist of minute 6-pointed stars.

Although hoarfrost and fog are not infrequent at this station, solar halos in connection therewith are of rare occurrence. The halo on this occasion was noticed as soon as the sun rose above the horizon, the north and south sides of the arc of 22° being bright, while the highest part of the curve was very faint. The whole circle of 22° radius was visible at 8:30 a. m. The sun itself was lost in a somewhat diamond-shaped yellowish white glare of light occupying the center of the circle. The bright portions of the halo extended below and in front of the hills about 1 mile distant, but the hills themselves were invisible. The halo had the appearance of being situated about three-fourths of a mile distant from the observer. At 8:15 a. m., the sun then being well above the horizon, the writer took position on a bridge that extended east and west and had at its southeast side a four-storied building. It was thus possible by moving along the bridge to place the building between the apparent position of the northern half of the halo and the observer, while the sun remained visible. In this position an arc of halo light remained visible against the dark background of the building and this arc corresponded with the remaining portion of the 22° -circle of the halo. By moving back and forth on the bridge this was repeatedly verified. Thus the halo was not formed on any one plane of the fog, but through a stratum of perhaps 2 or 3 miles thickness. Again, on facing the sun and looking at an angle downward toward the ground from the bridge, a vertical pillar of light was seen, somewhat faint but plainly visible. This was only noticeable against the dark background, being obscured in the sky by the general glare of light. The ice crystals in the air were visible to the eye as dancing particles of light moving in all directions, up, down, and sideways. No predominant direction of motion could be observed and it was evident that if they were spicules or prisms their planes must lie in all directions. No traces of the halo could be seen at 9:20 a. m., though fog was still present near the surface and did not entirely disappear all day. The appearance of the sky during the day was such as to apparently favor halo formation, but a close watch disclosed none.

LUNAR HALO OF JUNE 24-25, 1915, AT RICHMOND, VA.

June 24, 8:15 p. m.—An indistinct lunar halo was observed in very thin cirrus clouds and persisted until about 8:45 p. m. At 9 o'clock the vague outline of a 22°-halo was observed. The cirrus in which it appeared was then thin and fragmentary. These cirrus clouds gradually thickened until the sky became milky in appearance and the 22°-halo became very distinct. In addition two arcs were observed on either side of the moon at a distance of about 7° or 8°. These arcs were apparently portions of equal circles. Although the halo was brightest on its eastern edge no coloring was observed. The arcs were whitish in appearance and bore no resemblance to a corona. They faded about 10 p. m., and were not observed by me again. The halo was observed until about 11 p. m., at which time my view of it became obstructed.—*Thos. R. Brooks.*

9:25 p. m.—A pair of halos of concentric appearance was visible at 9:25 p. m., formed on cirri of very usual appearance, with some traces of striation from northeast to southwest. The larger of the halos was approximately 22° in radius, while the smaller one seemed to have a diameter equal to the radius of the larger. The color of both rings was of poor definition, and the only portion of chromatic distinctness was at the upper, zenithward, edge of the outer circle where a reddish hue could be detected on the inner side of the arc. A colorless paraseleena, somewhat questionable, and of the shape of a luminous ear of corn, might be included in the description of the phenomenon. This was coincident with the righthand portion of the larger halo, and extended directly away from the moon.

Measurements could not be made instrumentally and the only check on size that the writer was able to establish was by comparison with estimated distances from the horizon to the lower edge and the zenith distance of the upper edge, which were 15° and 20°, respectively. The appearance at a later hour was not observed.—*C. G. Andrus.*

10:20 p. m.—An ordinary lunar halo of 22° with a distinct reddish tint on its inner side was observed at this time. The circle was nearly complete except for a small gap on its lower side. There was also at this time a well-defined corona but without pronounced colors. At 10:40 p. m. the halo was still visible.—*E. A. Evans.*

10:40 p. m. to 10:55 p. m.—When first seen the sky was practically clear, stars being visible outside of, but not within the outer circle, of which there were two. There were, however, some thin high clouds, but neither their form nor movement could be discerned with certainty. Occasionally light wisps, evidently much below the cirrus level, swept rapidly across the halo, but without taking on any iridescence or appearing in anyway to become involved with the halo.

The whole phenomenon consisted of an inner ring and an outer arc, the lower portion of which—that is, the part nearest the horizon—being missing. Both circle and arc were concentric. The general appearance of the phenomenon was a trifle lacking in definition. The disk of the moon was not sharply discernible and the outer and inner edges of the arc were somewhat blurred; especially was this true of the outer, which faded at a distance of about 1 degree from the reddish inner edge. The tint lining the arc was brightest above and to the left of the moon and there may have been a faint paraseleena at that place, but its presence is doubtful in the mind of the observer. Presumably this was an ordinary halo of 22°, but from a rough approximation made by

carefully sighting over a pencil and afterwards constructing the angle it appeared to have been slightly less. The inner circle measured in the same way and with as much accuracy as possible under the circumstances was considered to have been one of 9° radius and the band to have been ½° wide. This, excepting of course the moon, was the most pronounced feature of the display. Both inside and outside edges of the circle were reasonably clear cut and the circle was complete and of silvery whiteness. The whole phenomenon reached its full development at or before the time I first observed it at 10:40 p. m.; at least shortly after that time it began to dissipate, since at 10:55 p. m. only the outer arc, somewhat more blurred than before, was to be seen. At 1:00 a. m. of the 25th the large arc was again seen, this time through small wisps of clouds, possibly of the alto-cumulus or high stratocumulus type.—*J. H. Kimball.*

THE PENETRATING RADIATION PRESENT IN THE ATMOSPHERE.¹

By A. GÖCKEL.

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The author briefly reviews the results obtained by other workers up to the present time, in various localities, under water, above water and ground, and at considerable heights in the atmosphere. The question of instrumental errors is taken up; the effects of changes of temperature and of humidity and of variations in barometric pressure are also considered. The author also avails himself of existing data, and those obtained from his own researches, in the endeavor to ascertain whether or not there are regular daily and also seasonal variations in the penetrating radiation. Experiments have been carried out by the author, with the aid of Wulf's "Strahler," as well as with an arrangement devised by himself, using Benndorf's electrometer (registration instrument). Measurements have been carried out at the Bodensee by balloons, above the ice of the Eiger and Grindelwald glaciers; on the Aletsch glacier, on the Eggishorn, on the snow of the Jungfrau ridge, in ice grottoes, as well as near the bare rocks; also in the proximity of grass land and gardens in Freiburg in Switzerland, together with other places. A few only of the results can be given here. The figures denote the production of ions per cubic centimeter per second. At the Bodensee, November 12, 1913—at 1 meter above water, 13.3; at 2 meters under water, 12.7; at 4 meters, 11.6; and at 6 meters, 10.6. In a garden at Freiburg, above the turf, 11.3 (dates not given); on the Aletsch glacier, at 2,800 meters, 10.7; near the gneiss rocks of the Trugberg, 19.6; and by the mica schist on the Eggishorn, 2,200 meters, 16.8. The strongest radiation observed by the author was that in the Lötschberg tunnel, through the granite, where the measurement gave 30 ions per cubic centimeter per second.

From his investigations the author draws the following deductions: (1) A depth of water of 3.5 meters is insufficient to absorb the radiation (cosmic?) coming from the atmosphere. (2) The observations on glaciers, as also with balloon ascents, show that there is an increase of the penetrating radiation with the height. (3) From solid crystalline rocks radiation is more intense than from cultivated alluvial soil. (4) A daily oscillation of the penetrating radiation is not noticeable in

¹ Phys. Zeits., Oct. 1, 1915, 16: 345-352.